4-2014

2014 Pesticide Safety: Cranberry Pollinator Update

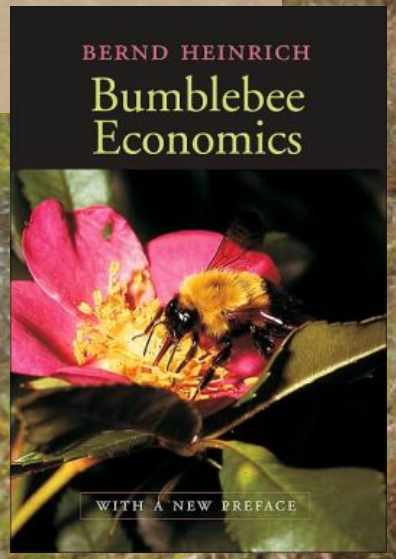
Anne Averill
University of Massachusetts - Amherst, averill@eco.umass.edu

Today's talk: April 2014

Cranberry pollinators
Updates about pesticides and bees
Things are getting complicated

Pollination in cranberry

"The association of bogs and bumble bees is not fortuitous. Bumble bees are tundra-adapted insects and the bogs are post-ice age islands of tundralike vegetation with which bumble bees have probably been associated for millions of years."



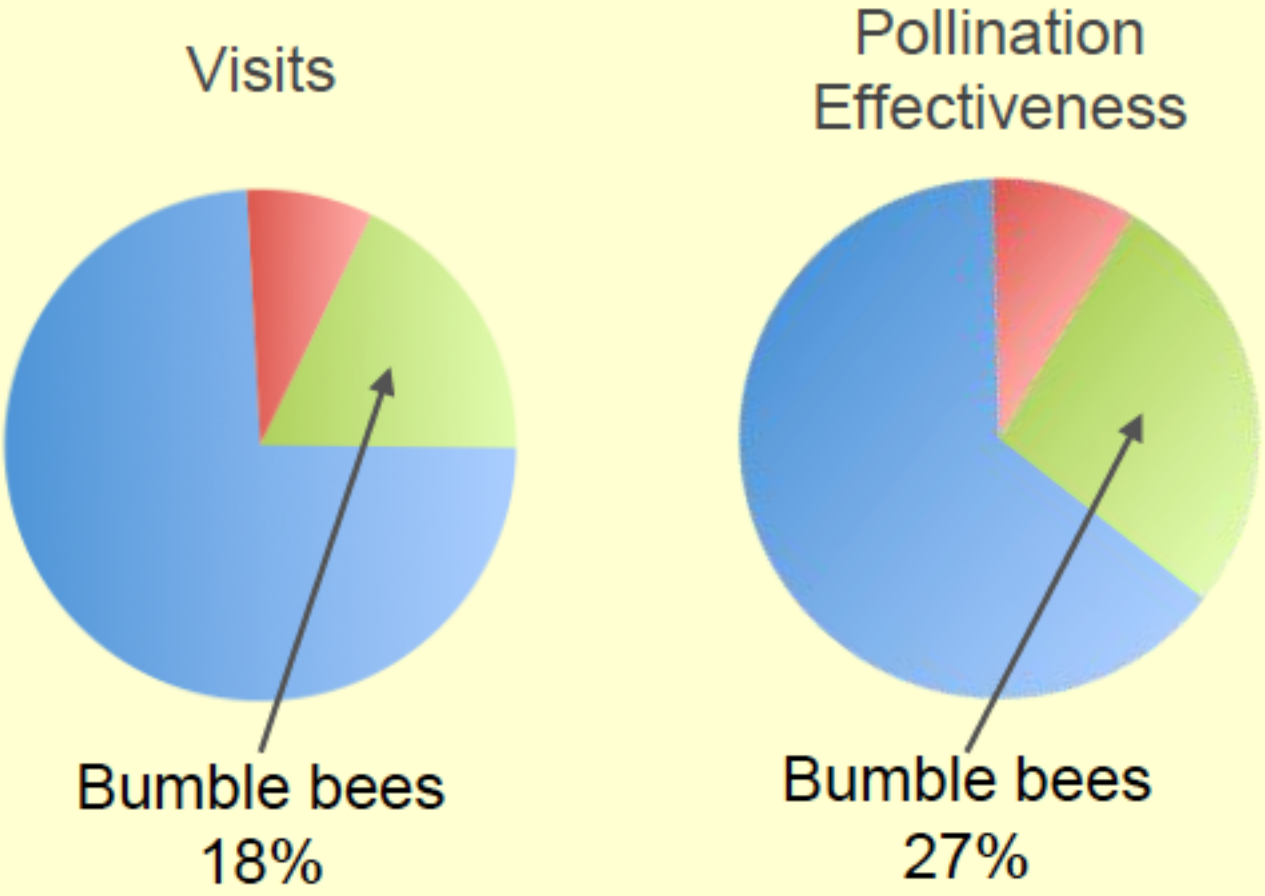
Pollination in cranberry

Bumble bees

Honey bees

Crop Pollination: New Jersey

Pollination Effectiveness of Main Bee Species



Slide adapted from Dr. Dan Cariveau
Department of Ecology, Evolution and Natural Resources, Rutgers University

The bumble bee queen
begins the spring
below ground
and all alone

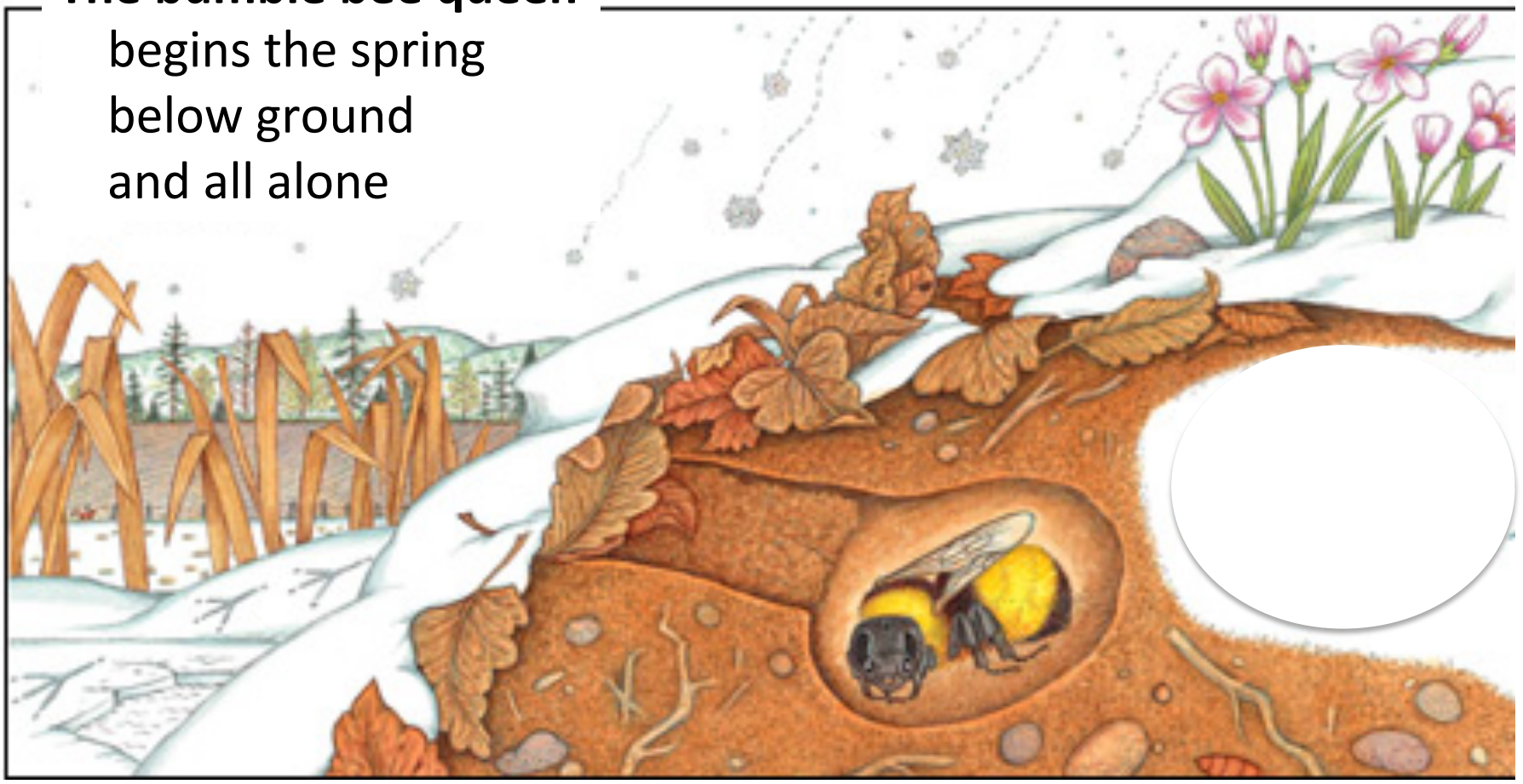


Illustration:Patricia j. Wynne

Blueberry and cranberry flowers

- Pollen release via 'buzz pollination':
  - Bee uses a vibration behavior (bumble bees and some other native bees)
  - Buzz pollination on cranberry
- Bumble bees far better adapted to these flowers

Honey bee just jiggles the flower with their legs

Photo: Cape Cod Cranberry Growers Assoc.

Bumble bees

Colony in thatch

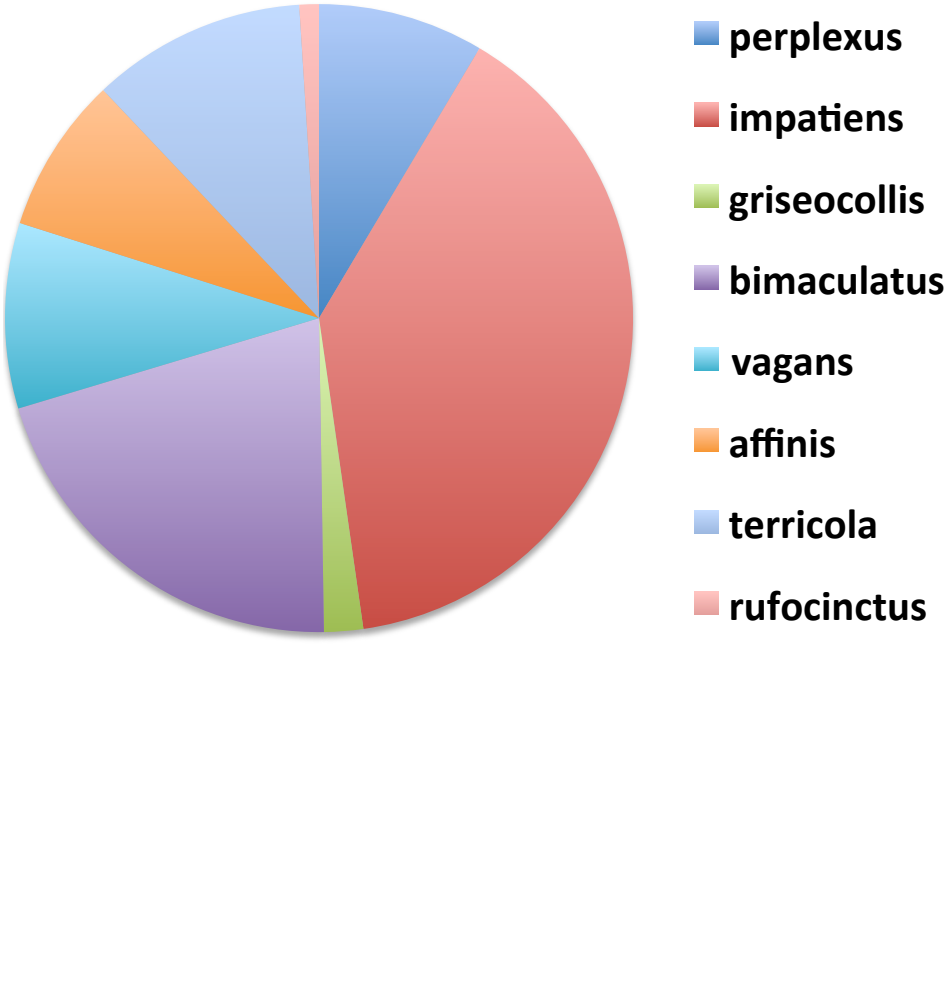
Iowa State Ext

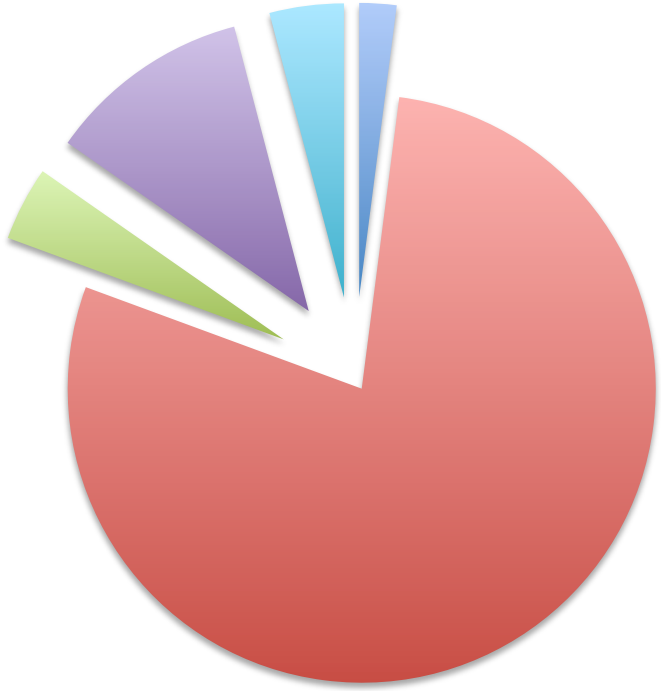
Colony with larvae in cells

hn

http://www.bbc.co.uk/nature/life/Bumblebee#p00gfxmw

1990 vs. 2013
loss of *Bombus* diversity in cranberry systems





Loss of *Bombus* species diversity

- **perplexus**
- **impatiens**
- **griseocollis**
- **bimaculatus**
- **vagans**

Expanding species may thrive in human-altered environments

Contracting species in fragmented populations may be more vulnerable to stressors

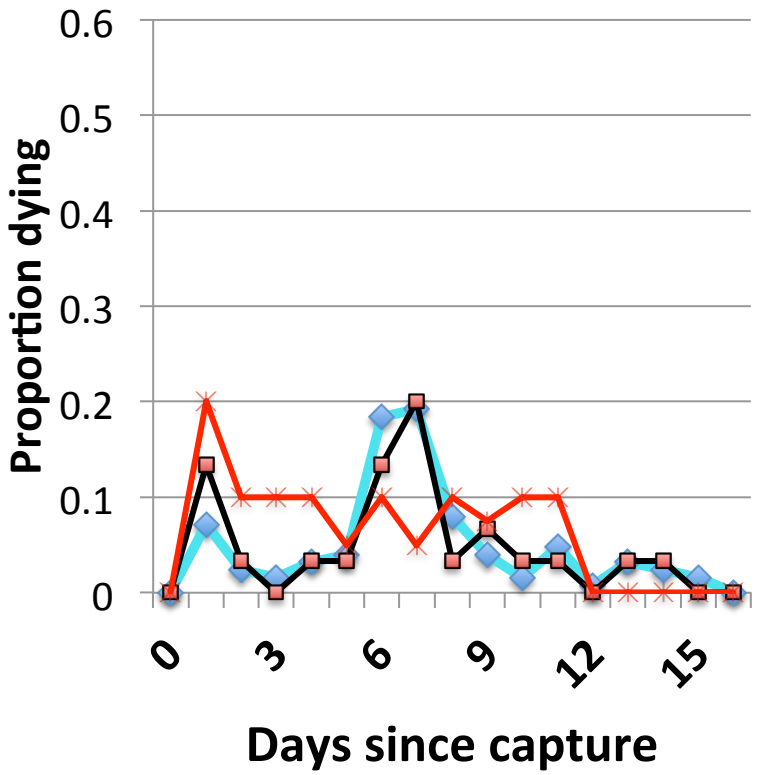
Illus: Elaine Evans

Unintended evaluation of pesticide effects

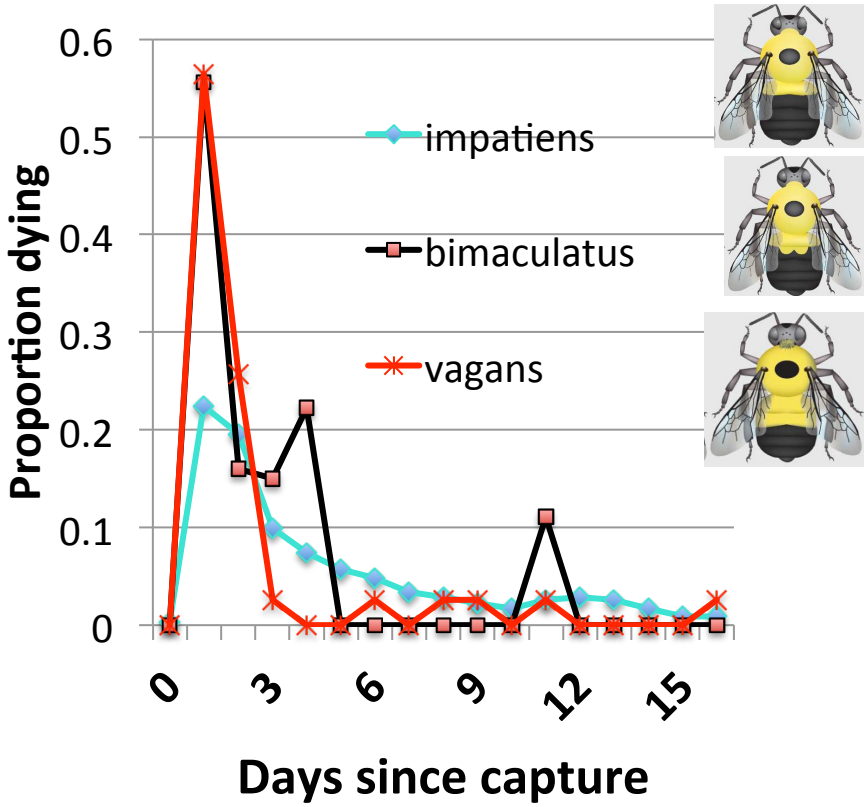
- We field collected bumble bees and held them in lab for pathogen and parasitoid infection
- After bloom sprays started, survivorship crashed
- Fungicides tank-mixed with insecticide had been applied
  - All cleared as bee safe

Bloom spray tank mixes require evaluation

Early bloom, pre-spray

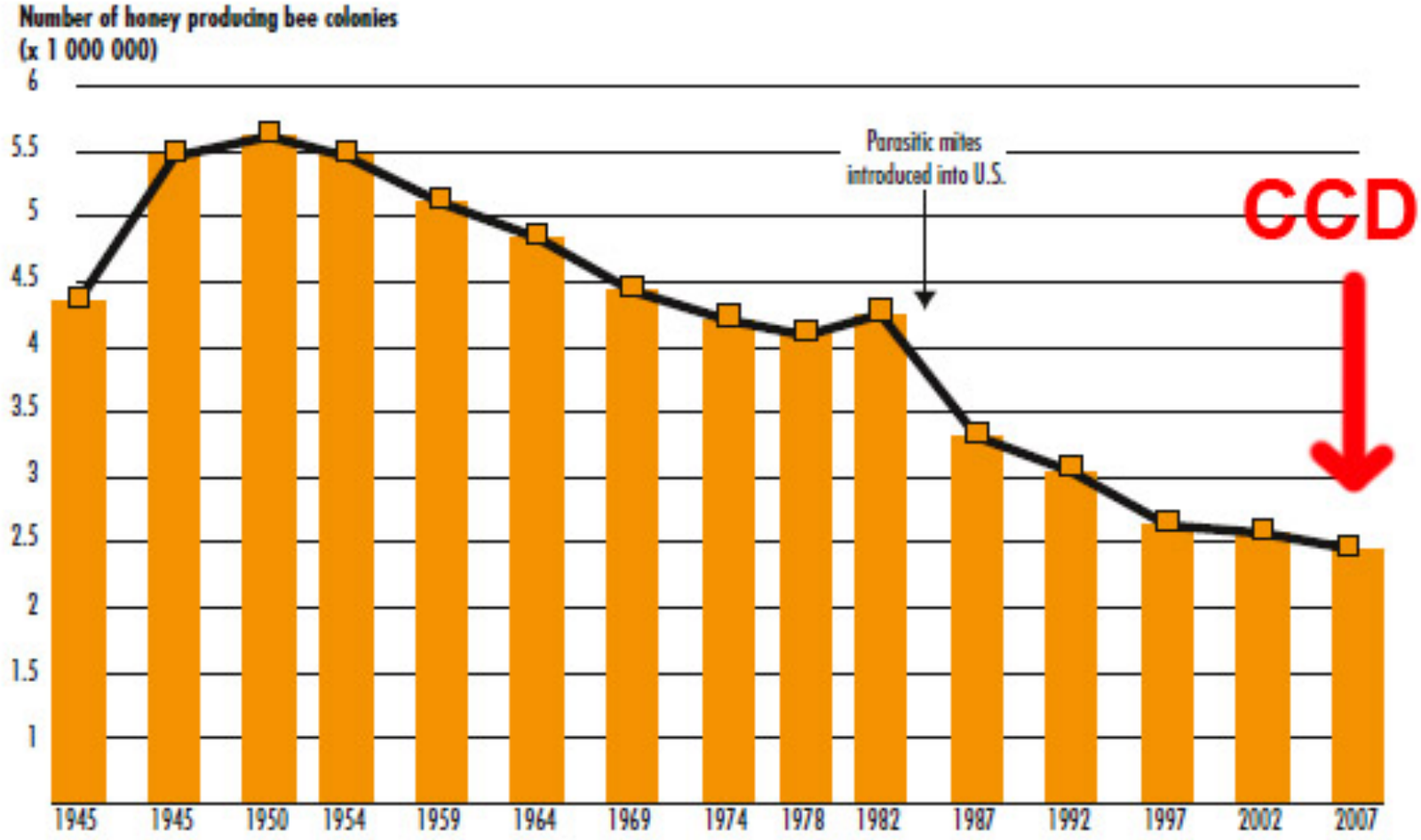


Mid bloom, during spray



Honey bees are in decline

Figure 4: US honey-producing colonies



Data source: U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) NB: Data collected for producers with 5 or more colonies. Honey producing colonies are the maximum number of colonies from which honey was taken during the year. It is possible to take honey from colonies which did not survive the entire year.

Honey Bee Losses

Annual losses…

Before CCD (1995-2006):

15% - 22% per year

After CCD (2006-today):

29% - 36% per year

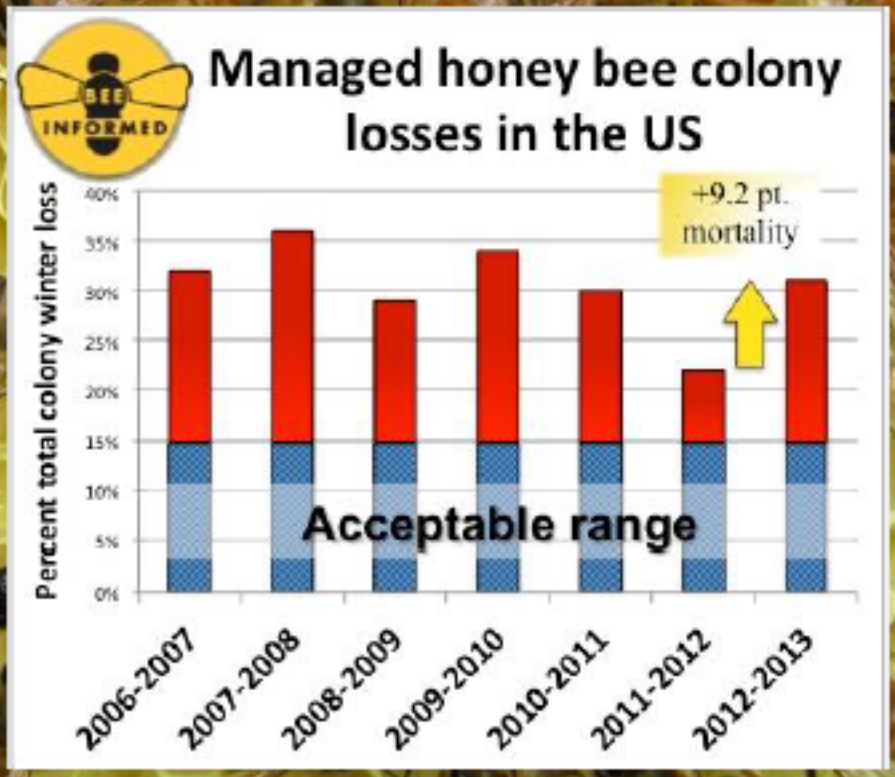
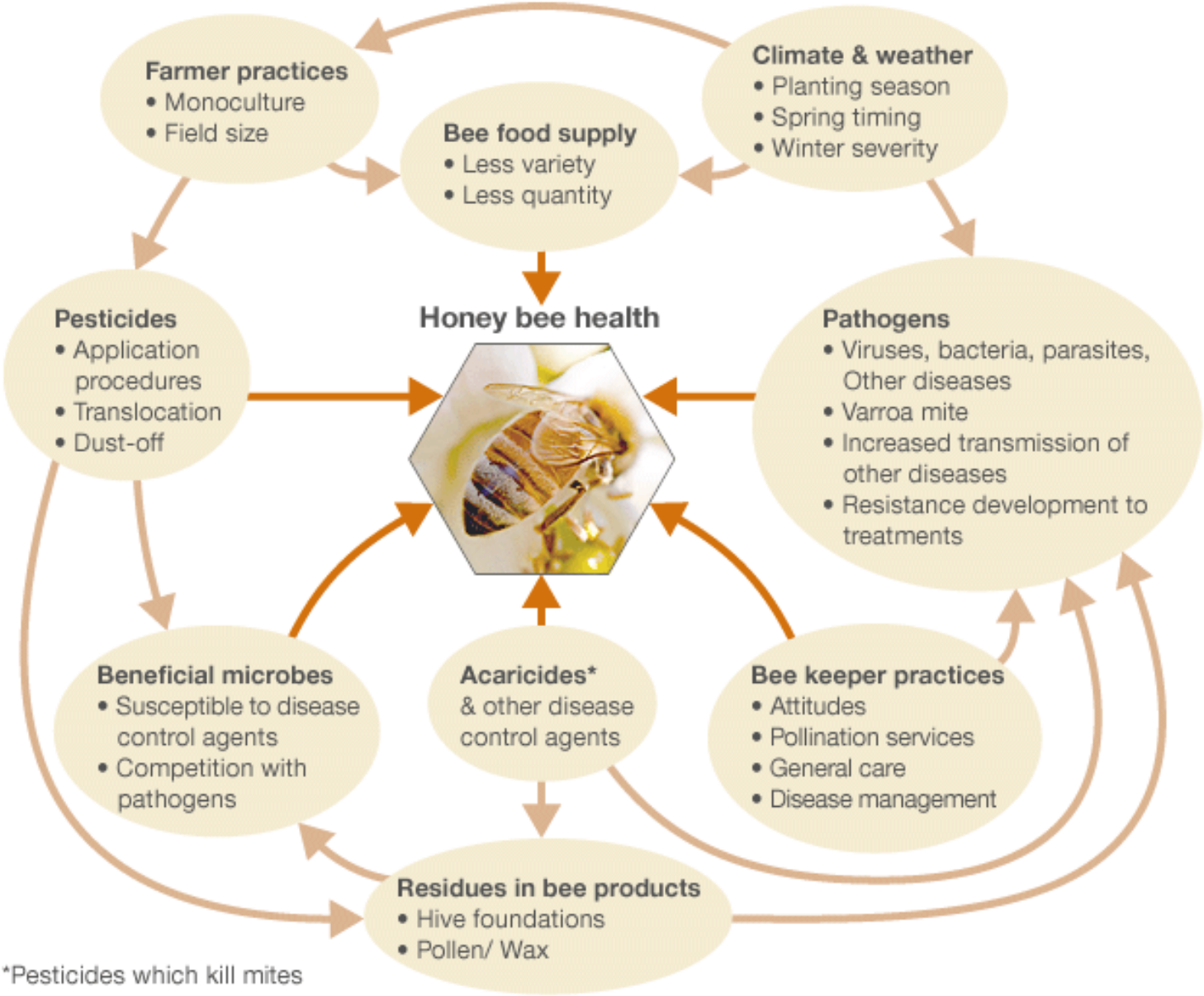


Photo: Eric Mader, (Xerces Society)

Stress factors in honey bee populations



*Pesticides which kill mites

Source: OPERA Bee health in Europe, 2013

70-100% decline of feral colonies since 1990s

Photo: Dave McKenna

Results: Rising Cost of Commercial Pollination

Cranberry hive rental:

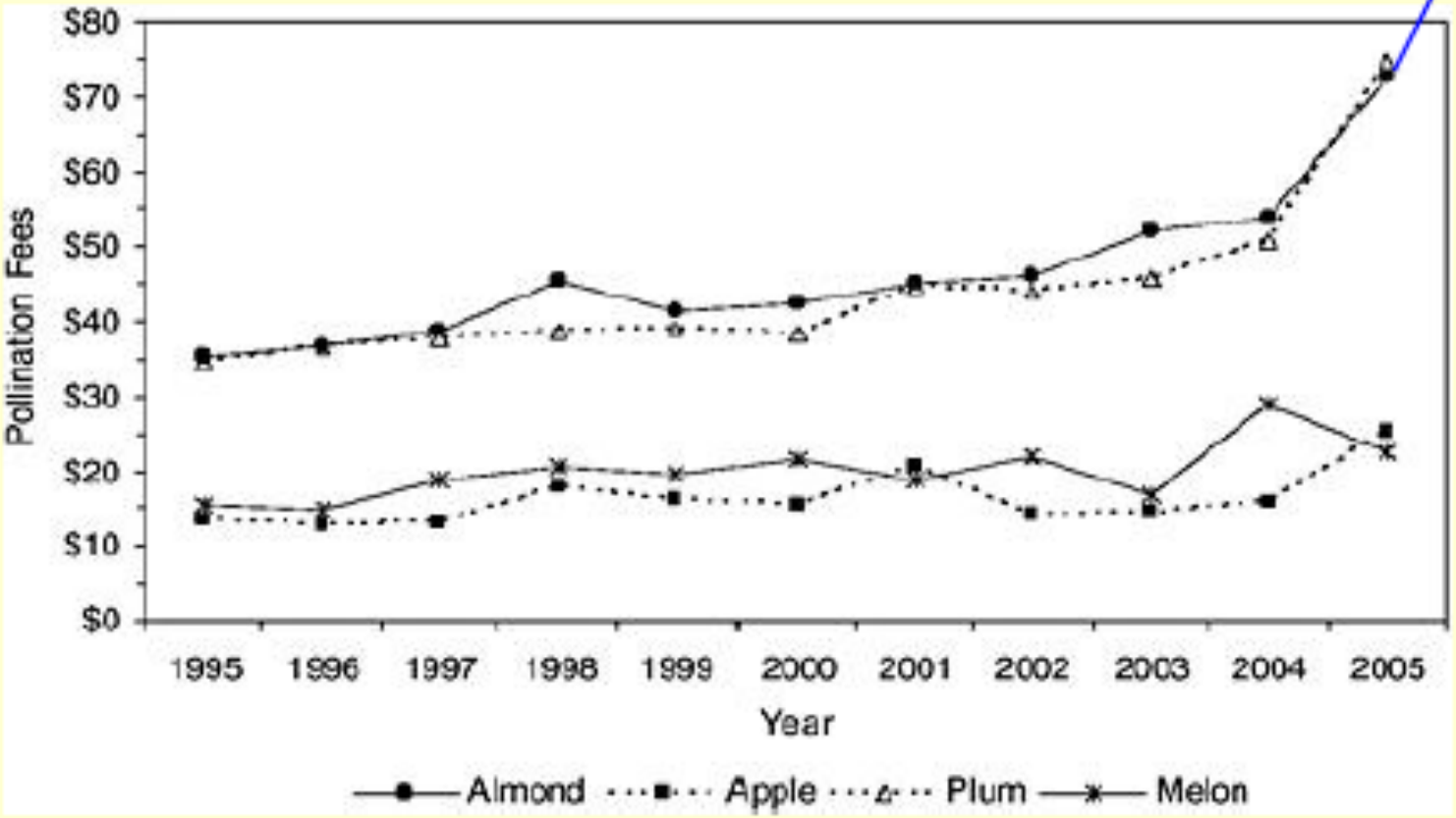
- Generally, doubled in price
- In New England, timing can be off when blueberries are blooming late
- In Maritimes of Canada, supply far below demand
- Wisconsin beekeepers anticipating an increase to $100 per hive

Photo: Mace Vaughan (Xerces Socoiety0

Results: Rising Cost of Commercial Pollination

Honey bee colony rental rates for selected California crops, 1995–2005.

Plus almonds, 2006-2013



2006

2007

California almond bloom: huge pollination demand

Photo: Anthony Dunn

Almond pollination

- 1.7 million hives utilized
- This year, when bees were released from the orchards, beekeepers reported dead adult bees, and dead, dying, and deformed brood.
- Beekeepers felt that there were issues surrounding tank mixes of fungicides and insect growth regulators.

IGRs interfere with hormones of insect

- Treated larvae may be unable to successfully change from larva>pupa>adult.
- Immature stages may be unable to molt

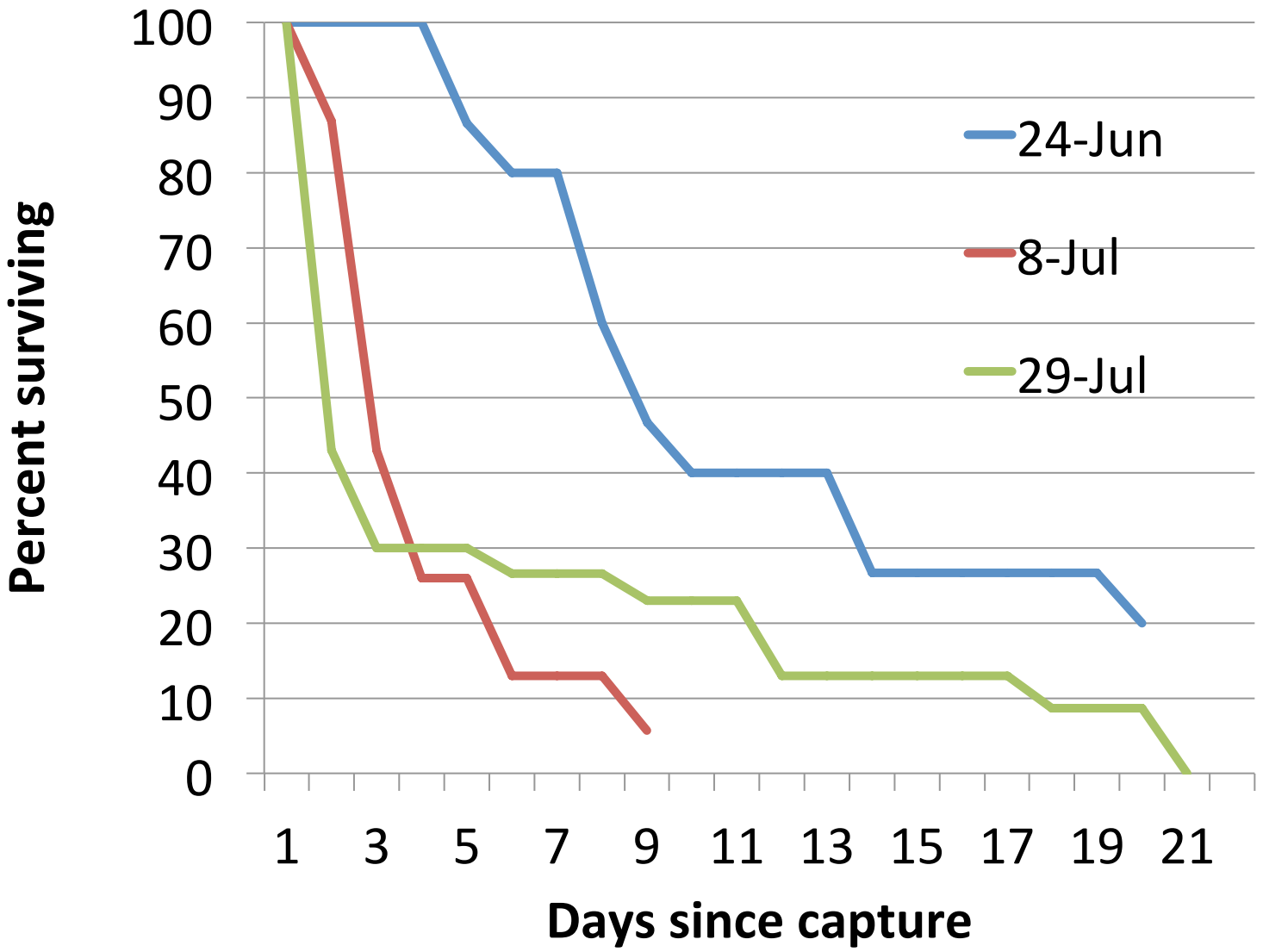
- Fungicides and IGRs, when applied alone, are believed to have no bee toxicity

Bumble bees were collected from bogs 3-4 times

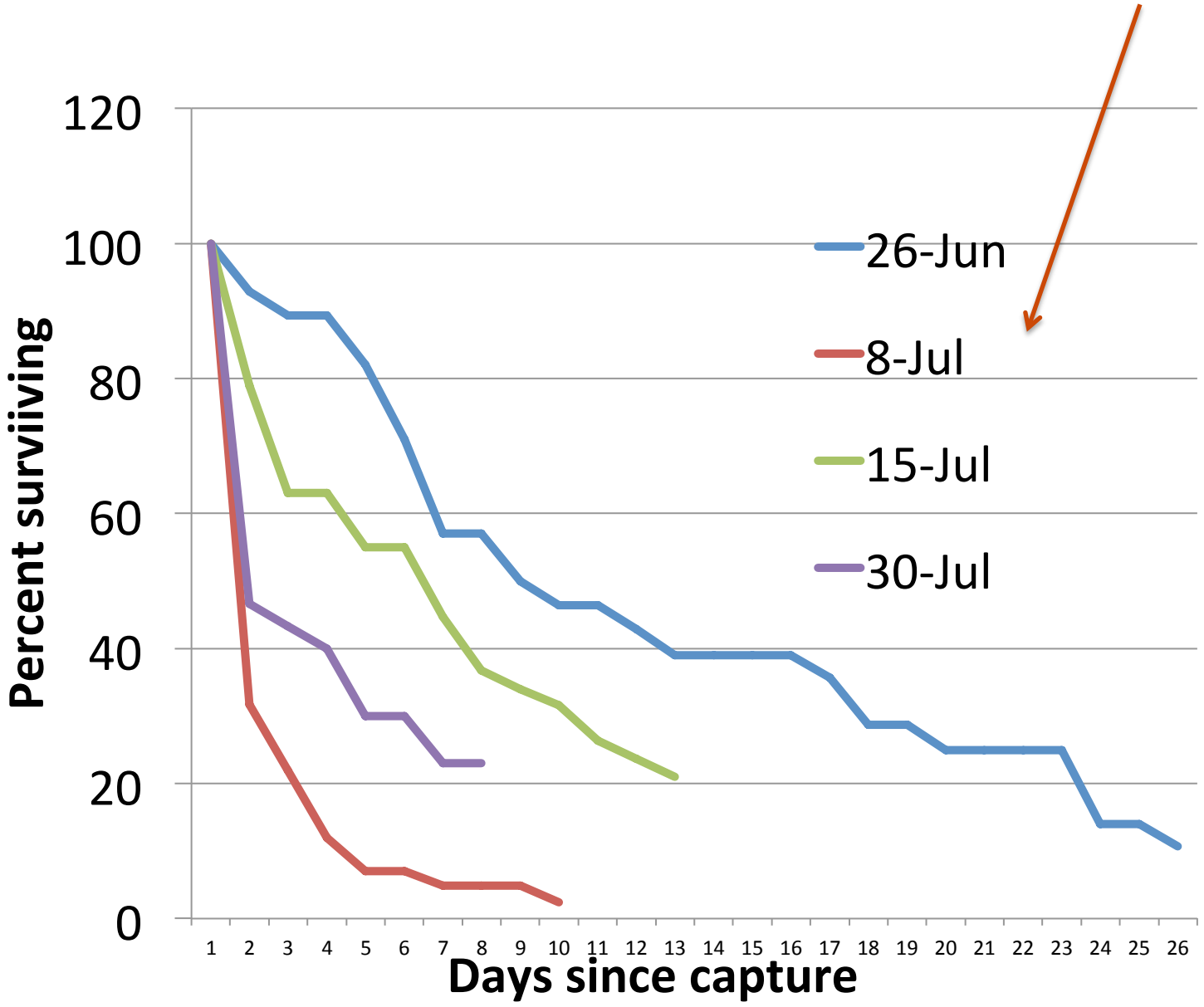
Unintended evaluation of pesticide effects

- We field collected bumble bees and held them in lab for pathogen and parasitoid infection
- After fungicide-insecticide mixed sprays started, survivorship crashed
- All cleared as bee safe

Bloom pesticides began July 4



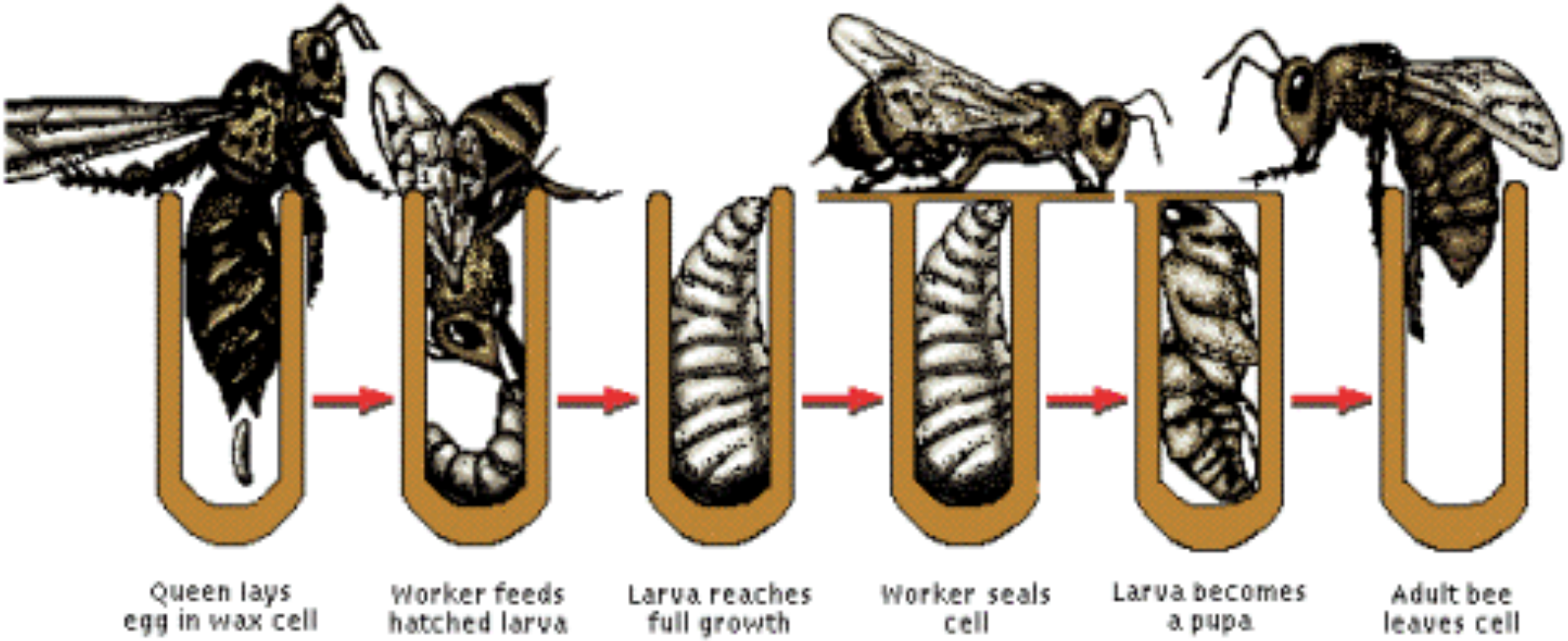
Non-conventional site, Intrepid + fungicide



Sublethal effects, e.g. contamination at the colony

- Bee survives, but returns to hive with contaminated body, nectar, and pollen
- Pollen and nectar stored
  - Eaten by larvae over time
  - Slow acting toxins or chronic doses

Honey bee life cycle



What's in the pollen?

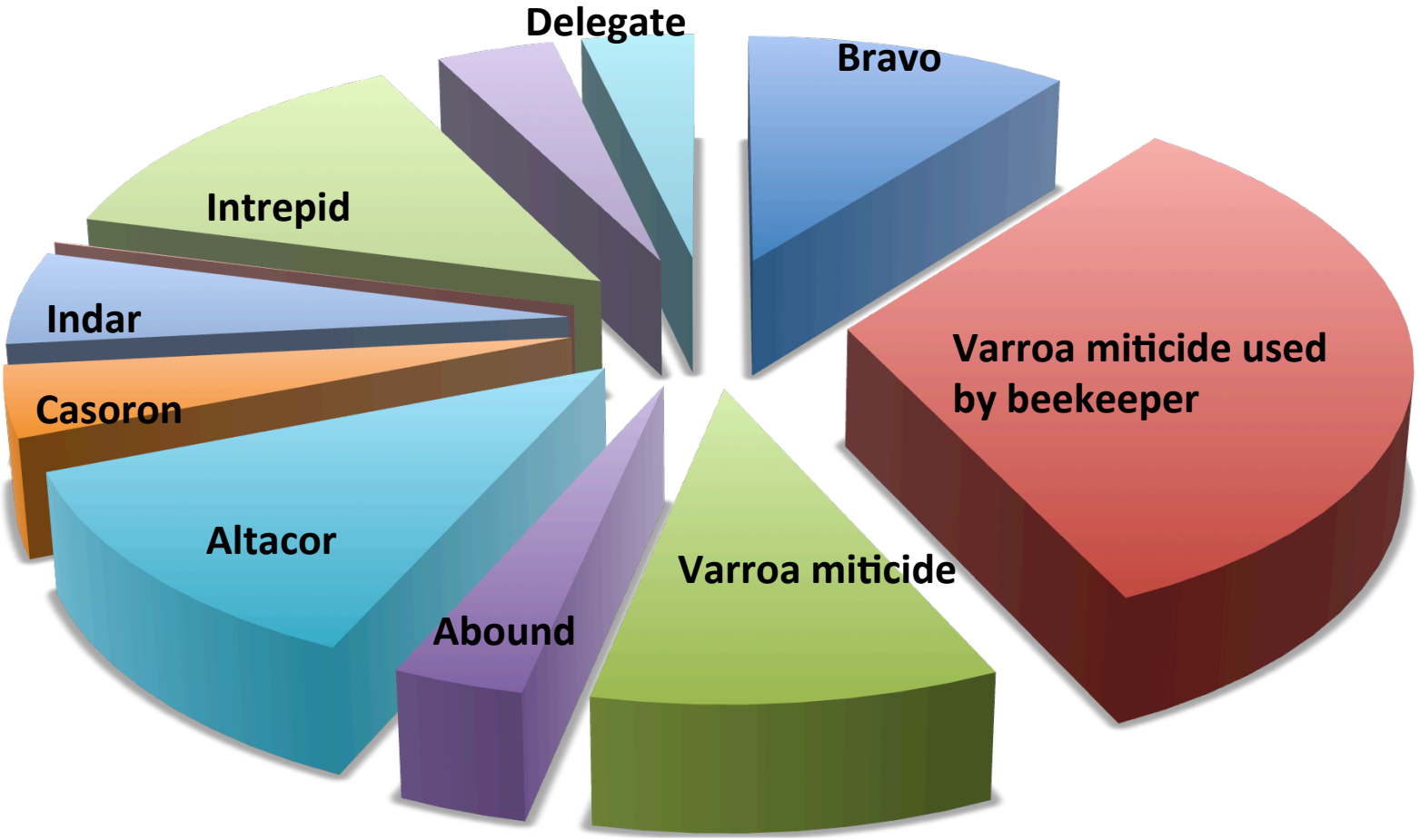
Honey bees with pollen loads

Pollen traps attached to hives during cranberry bloom

Mike Toboyek


© Rober Snyder 2005-2012

Proportions of pesticides at highest pesticide load site



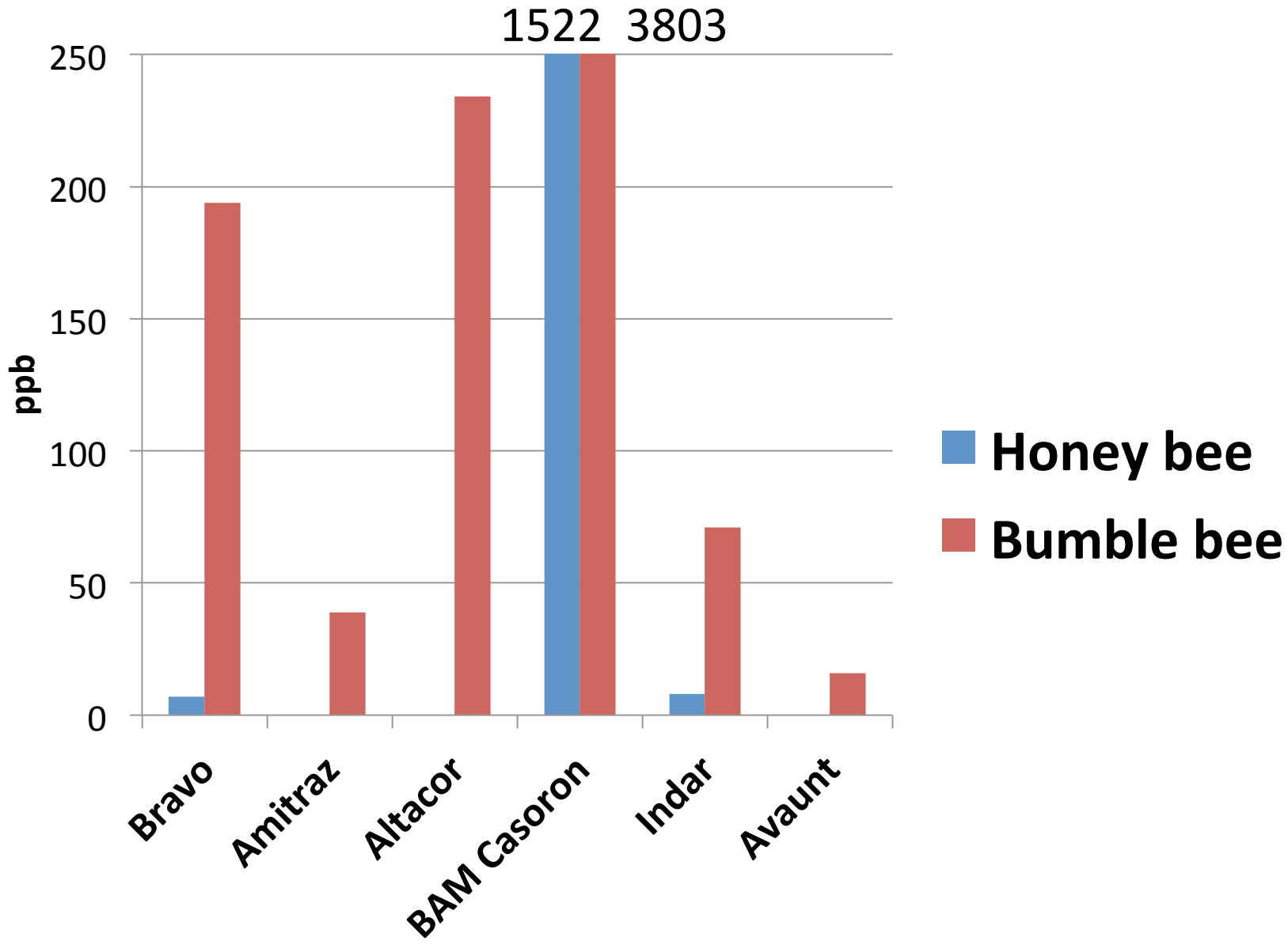
Compare bumble bee pollen loads

Bumble bees on cranberry:
Lots of cranberry pollen is found
in pollen loads

Bumble bee

Honey bee

Pollen load analysis for pesticides: same site




© Dwight Kuhn

OPEN ACCESS Freely available online

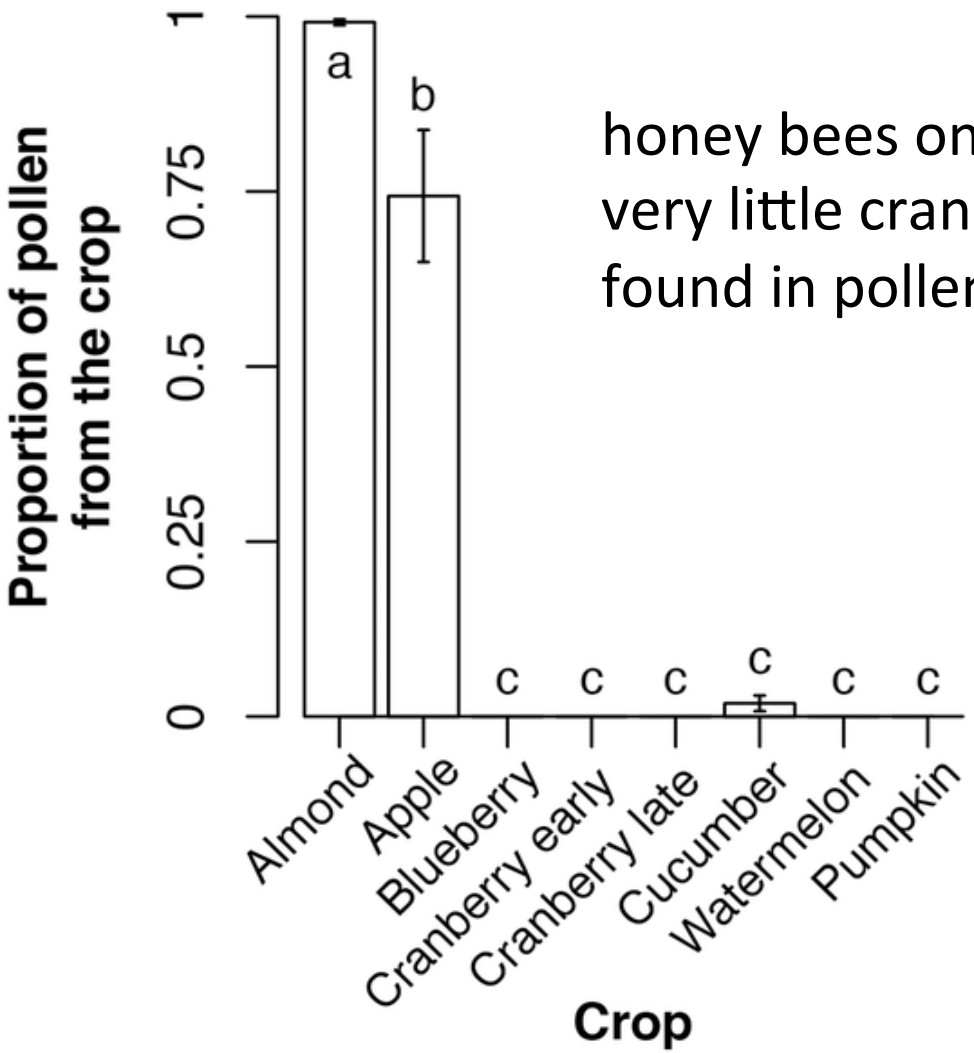
PLOS | ONE

Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema ceranae*

Jeffery S. Pettis[1], Elinor M. Lichtenberg[2], Michael Andree[3], Jennie Stitzinger[2], Robyn Rose[4], Dennis vanEngelsdorp[2]*

1 Bee Research Laboratory, USDA-ARS, Beltsville, Maryland, United States of America, **2** Department of Entomology, University of Maryland, College Park, College Park, Maryland, United States of America, **3** Cooperative Extension Butte County, University of California, Oroville, California, United States of America, **4** USDA-APHIS, Riverdale, Maryland, United States of America

Pollen collections from crop where honey bees were located



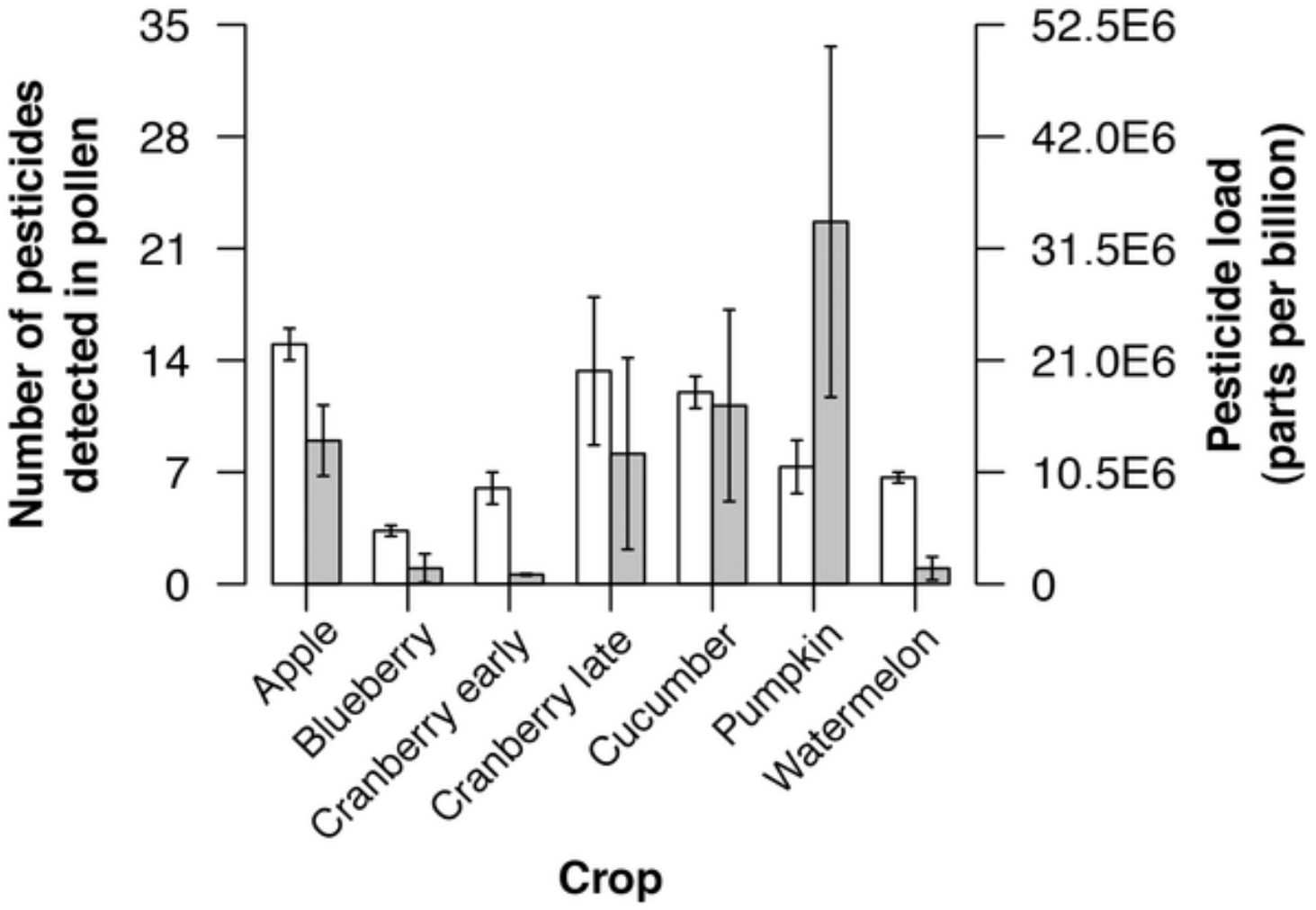
honey bees on cranberry: very little cranberry pollen is found in pollen loads

Pettis JS, Lichtenberg EM, Andree M, Stitzinger J, et al. (2013) Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae. PLoS ONE 8(7): e70182. doi:10.1371/journal.pone.0070182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0070182

Pettis et al. conclusion

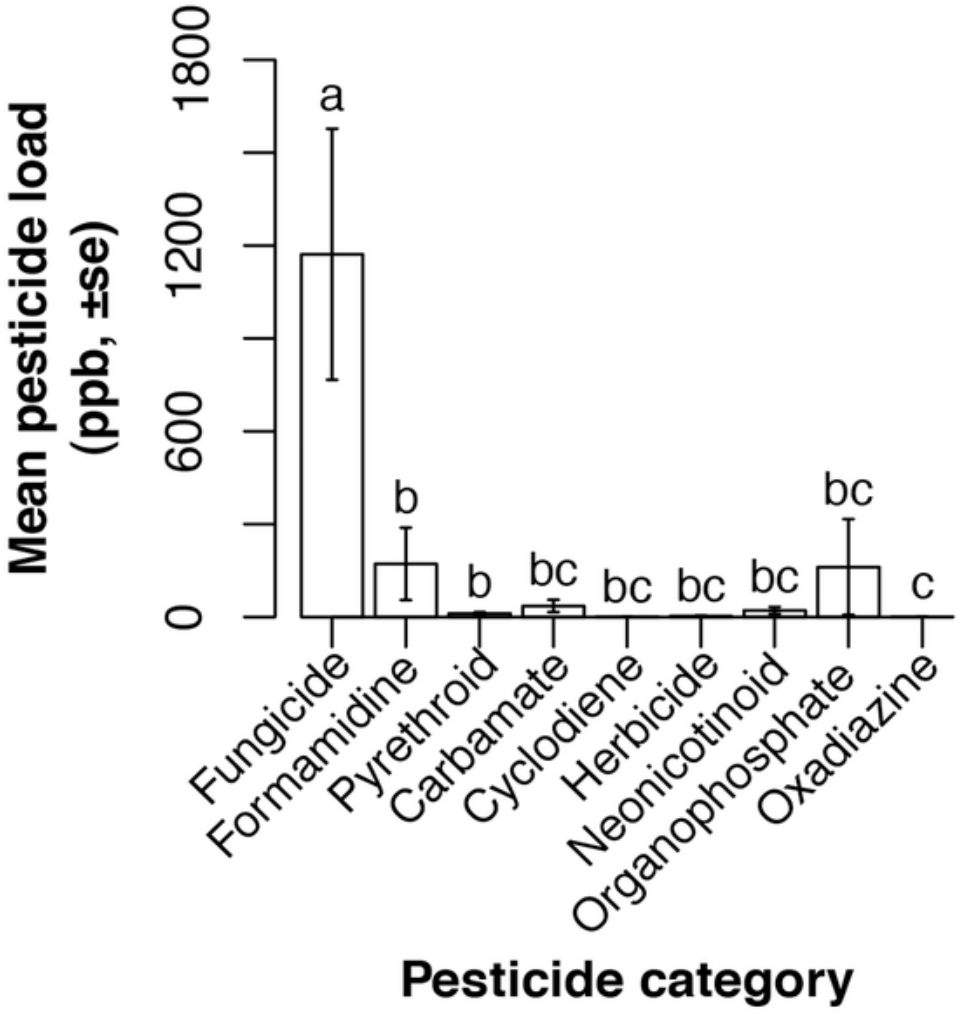
- pollen samples contained an average of nine different pesticides, ranging as high as 21 pesticides in one cranberry field.
- fungicides were present at high levels in both crop and non-crop pollen collected by bees
- some bee colonies are being exposed to incredibly high levels of chemicals.
- research suggests that simultaneous exposure to multiple pesticides decreases lethal doses

Figure 2. Pesticide diversity found in pollen samples, but not pesticide load, varied by crop.

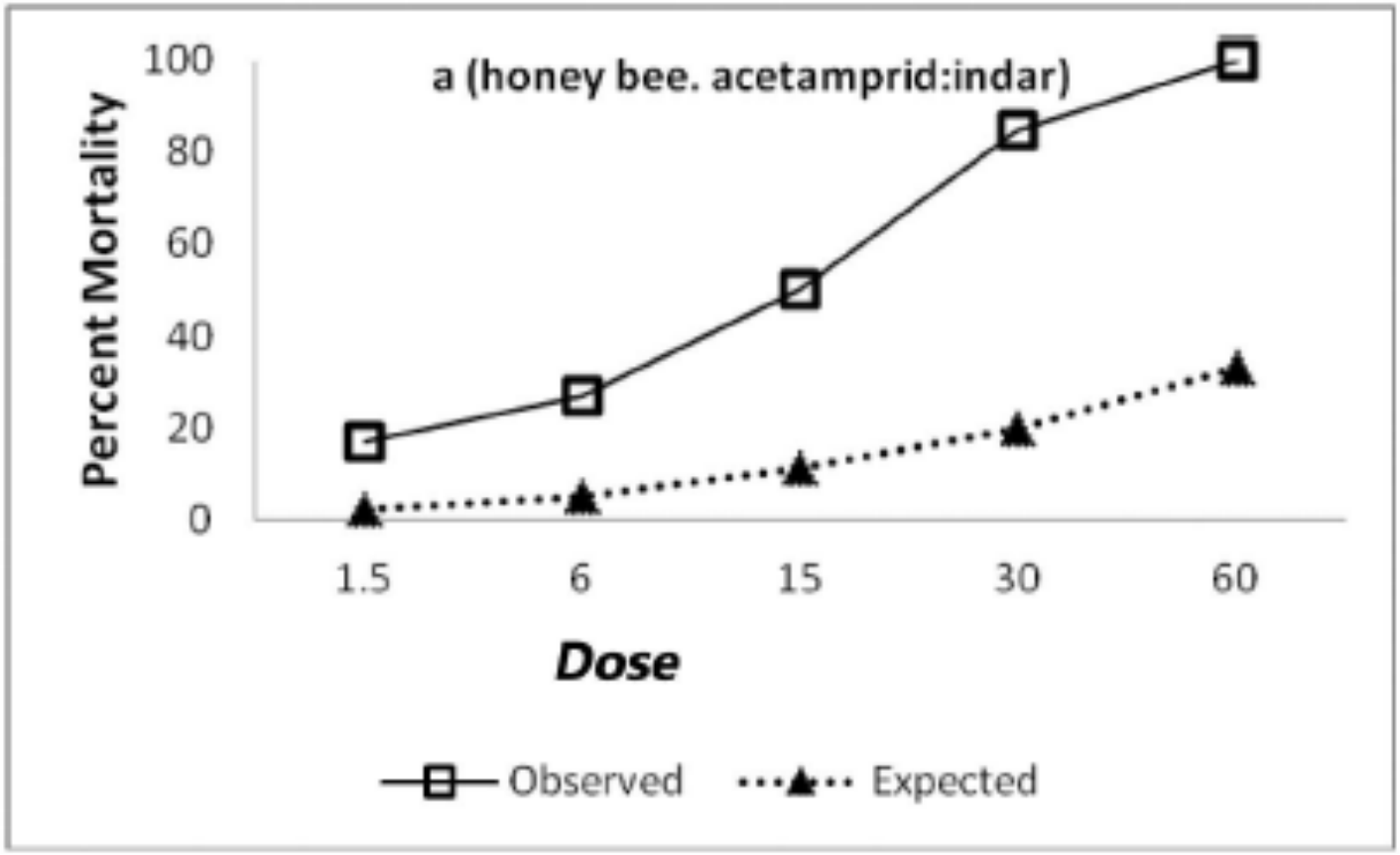


Pettis JS, Lichtenberg EM, Andree M, Stitzinger J, et al. (2013) Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae. PLoS ONE 8(7): e70182. doi:10.1371/journal.pone.0070182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0070182

Figure 4. Load varied by pesticide category.



Pettis JS, Lichtenberg EM, Andree M, Stitzinger J, et al. (2013) Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae. PLoS ONE 8(7): e70182. doi:10.1371/journal.pone.0070182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0070182



OPEN ACCESS Freely available online

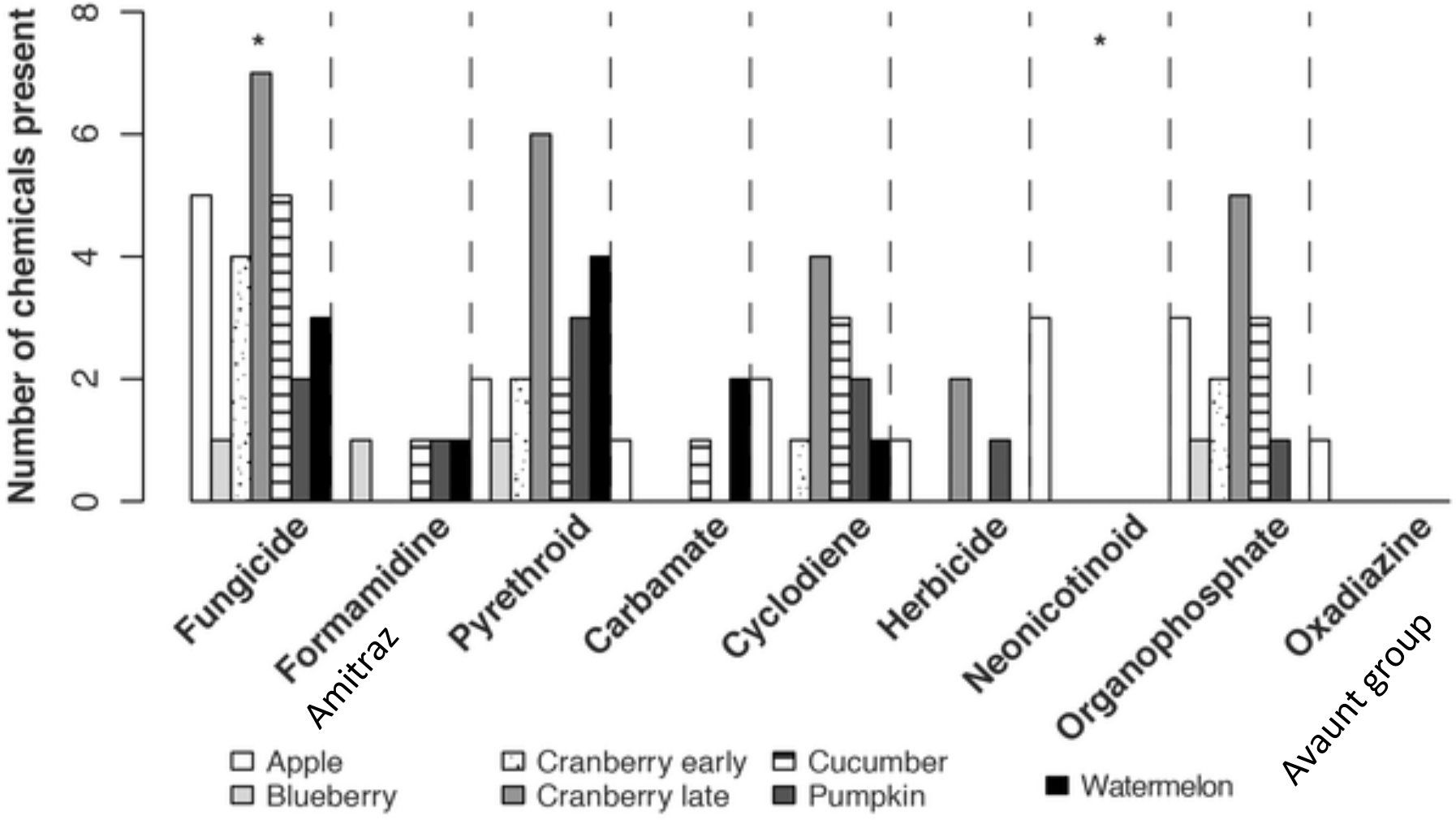
PLOS ONE

Comparative Toxicities and Synergism of Apple Orchard Pesticides to *Apis mellifera* (L.) and *Osmia cornifrons* (Radoszkowski)

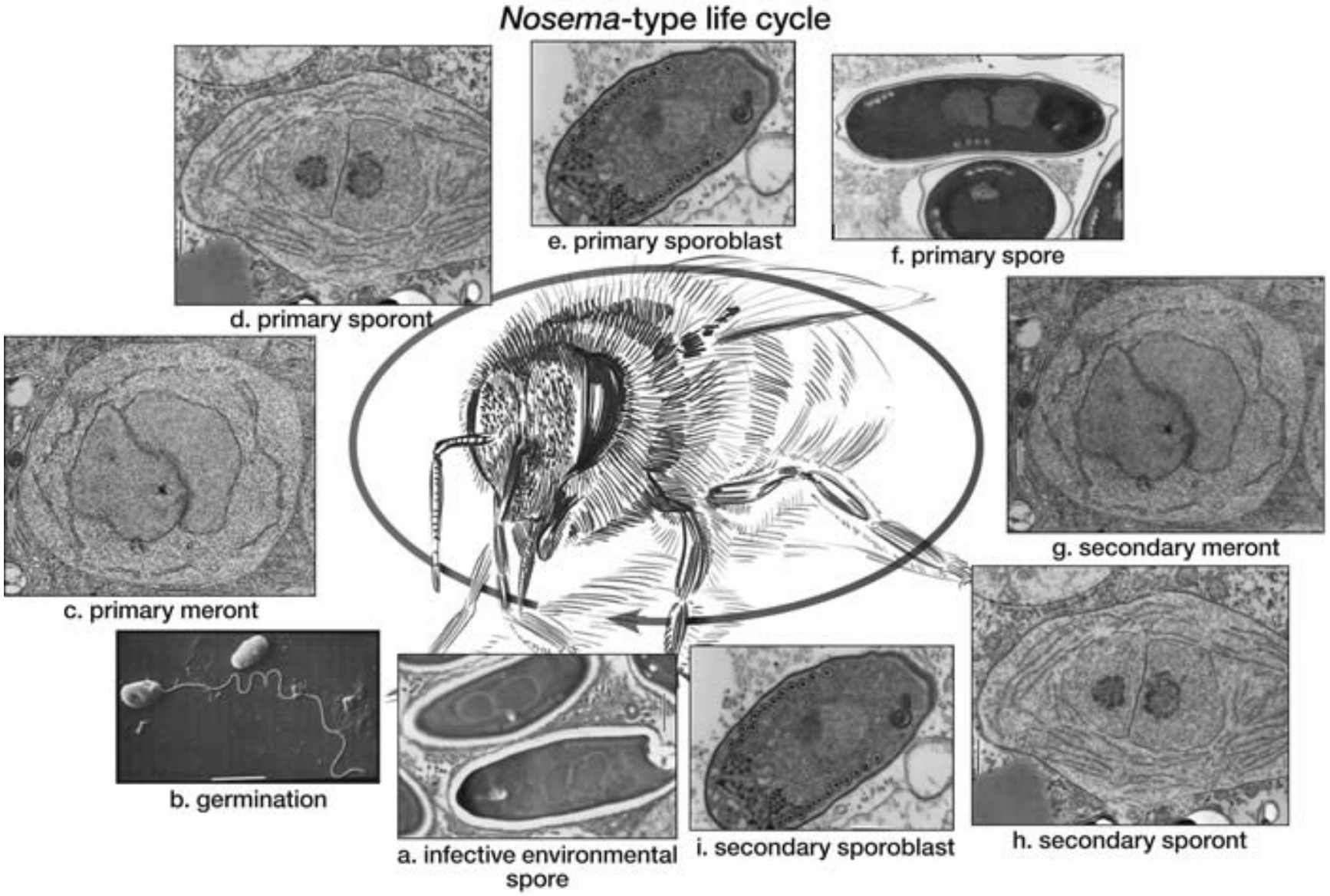
David J. Biddinger[1,3], Jacqueline L. Robertson[2]*, Chris Mullin[3], James Frazier[3], Sara A. Ashcraft[3], Edwin G. Rajotte[3], Neelendra K. Joshi[1,3], Mace Vaughn[4]

1 Fruit Research and Extension Center, Pennsylvania State University, Biglerville, Pennsylvania, United States of America, **2** USDA Forest Service PSW Station, Albany, California, United States of America, **3** Department of Entomology, Pennsylvania State University, University Park, Pennsylvania, United States of America, **4** The Xerces Society, Portland, Oregon, United States of America

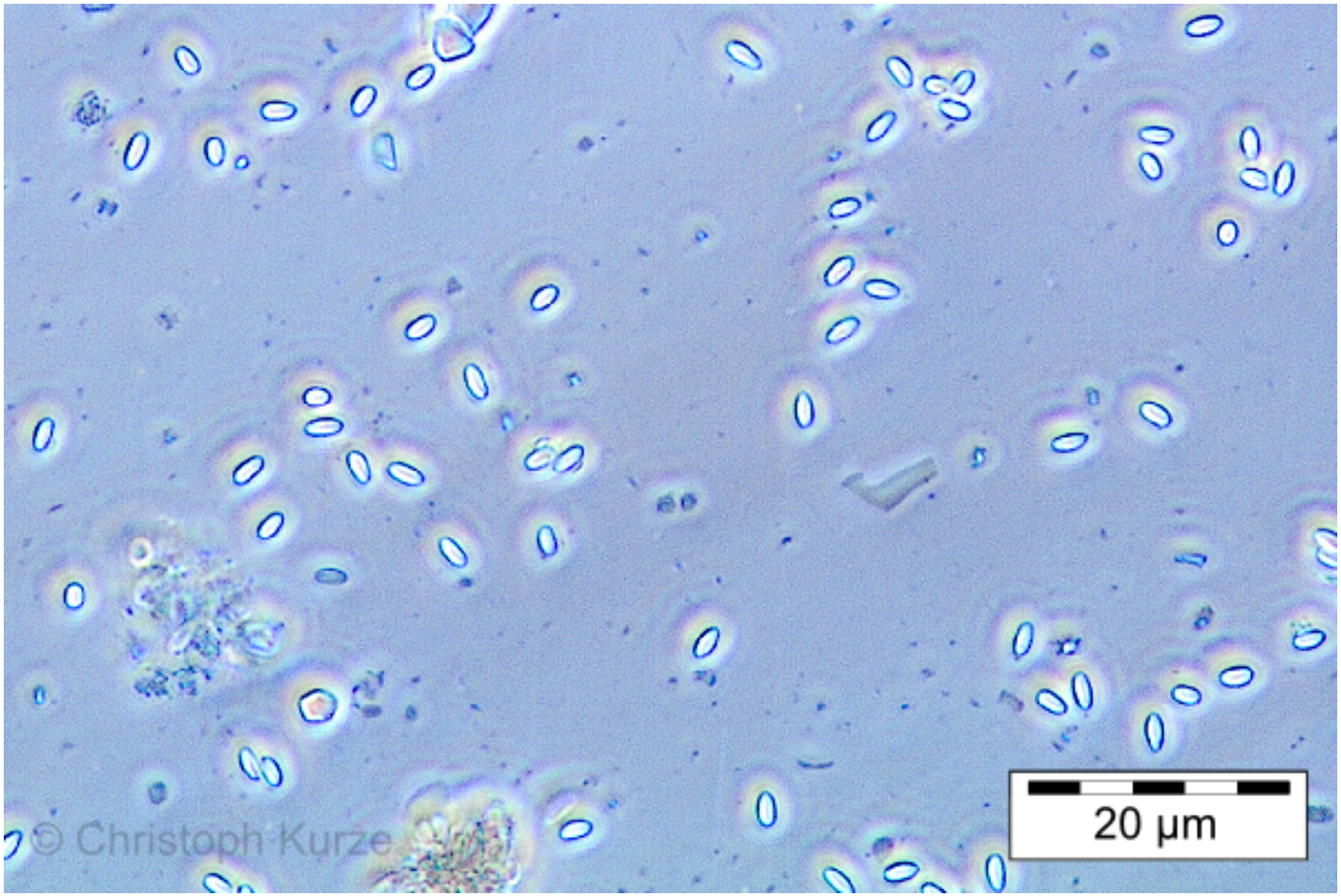
Figure 3. Fungicide and neonicotinoid diversities varied by crop.



Pettis JS, Lichtenberg EM, Andree M, Stitzinger J, et al. (2013) Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae. PLoS ONE 8(7): e70182. doi:10.1371/journal.pone.0070182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0070182

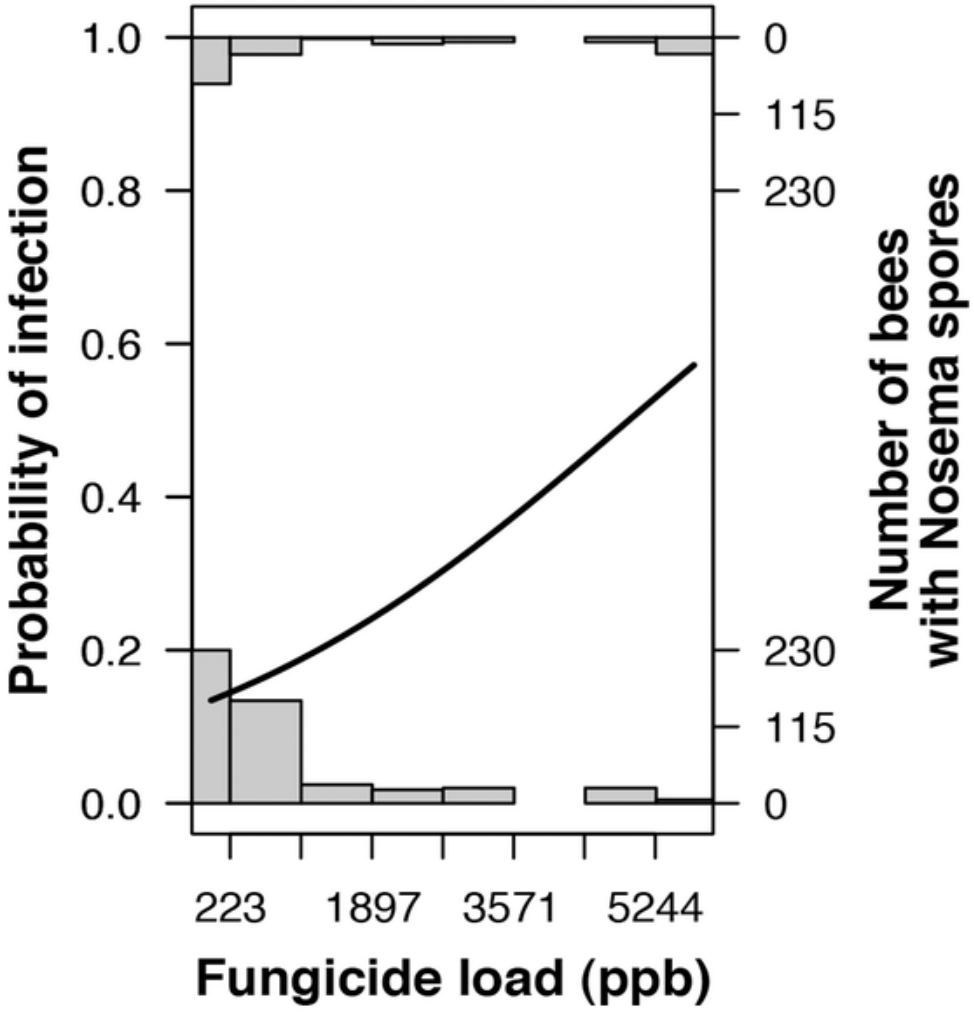

Nosema-type life cycle
d. primary sporont
e. primary sporoblast
f. primary spore
g. secondary meront
c. primary meront
b. germination
a. infective environmental spore
i. secondary sporoblast
h. secondary sporont

The oval-shaped *Nosema* spores appear typically bright with dark smooth edges under phase-contrast light microscope (magnification: 400x).



- Two fungicides (chlorothalonil [Bravo] and pyraclostrobin), and two miticides used by beekeepers to control varroa infestation (amitraz and fluvalinate) had a pronounced effect on bees' ability to withstand parasite infection.

A pollen sample's fungicide load significantly affected *Nosema* prevalence among bees fed that pollen



Pettis JS, Lichtenberg EM, Andree M, Stitzinger J, et al. (2013) Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen Nosema ceranae. PLoS ONE 8(7): e70182. doi:10.1371/journal.pone.0070182
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0070182

- These increases may be linked to insecticide-induced alterations to immune system pathways, which have been found for several insects, including honey bees


IS MY
HONEY?
BEE
WISE
SAVE THE BEES
BAN POISONOUS
NICOTENOID"

Mass poisoning of bumble bees in Oregon

- Tens of thousands dead under trees in mall lot
- Occurred after neonicotinoid was sprayed on linden trees to control aphids
  - Aphids were secreting a sticky residue while feeding, making them a nuisance to parked cars.

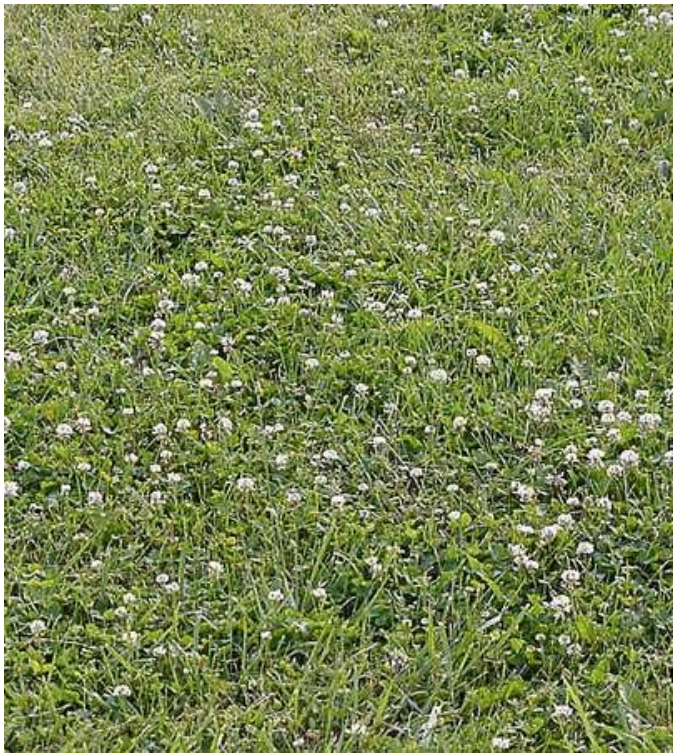
- The neonicotinoid pesticide dinotefuran (Safari) was applied by commercial applicator

Rich Hatfied, Xerces Society

Neonicotinoid toxicity to bees: acute contact LD_{50}

clothianidin	.014 µg	Poncho, Acceleron, Belay, Clutch, Celero, Arena
imidacloprid	.024 µg	Admire, Advantage, Merit, Premise, Gaucho
thiamethoxam	.030 µg	Actara, Platinum, Cruiser
dinotefuran	.075µg	Venom, Safari
acetamiprid	7.1µg	Assail, Tristar
thiacloprid	14. 6µg	Calypso

Recent (2013) neonicotinoid study in lawn setting



- Spring (May) drench applications are made for soil pests
- Lawns with blooming clover were treated

OPEN ACCESS Freely available online

PLOS ONE

Assessing Insecticide Hazard to Bumble Bees Foraging on Flowering Weeds in Treated Lawns

Jonathan L. Larson, Carl T. Redmond, Daniel A. Potter*

Department of Entomology, University of Kentucky, Lexington, Kentucky, United States of America

Recent neonicotinoid study in lawn setting

- Compared drench of bee safe diamide (chlorantraniliprole) vs. neonicotinoid (chlothianidin)
- Watered in lightly

- (Acelypryn vs. Arena)
- Cranberry equivalents = Altacor vs. Belay

- Allowed bumble bees to forage in screened enclosures for 6 days

- Included a no-spray control treatment

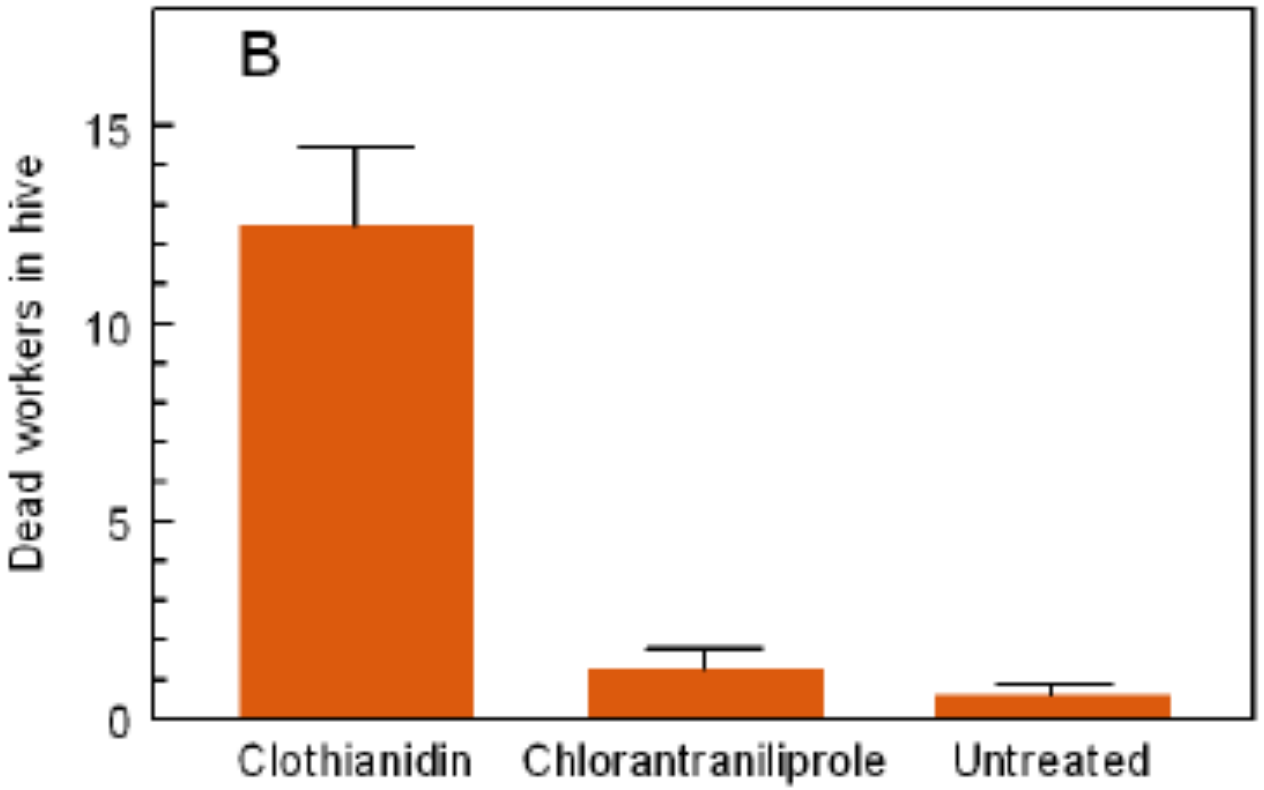


Figure 1. Foraging and dead workers during exposure to treated turf. Mean (±SE) numbers of (A) bees foraging in enclosures during two mid-afternoon inspections on the 5th and 6th days, and (B) dead non-callow workers observed in hives on the 6th day of exposure of bumble bee colonies to weedy lawn turf with residues of a neonicotinoid (clothianidin) or anthranilic diamide (chlorantraniliprole) applied at label rates. For foragers, clothianindin<chlorantraniliprole=untreated on both census dates; for dead workers, clothianidin >chlorantraniliprole=untreated (Friedman tests, $P<0.001$).

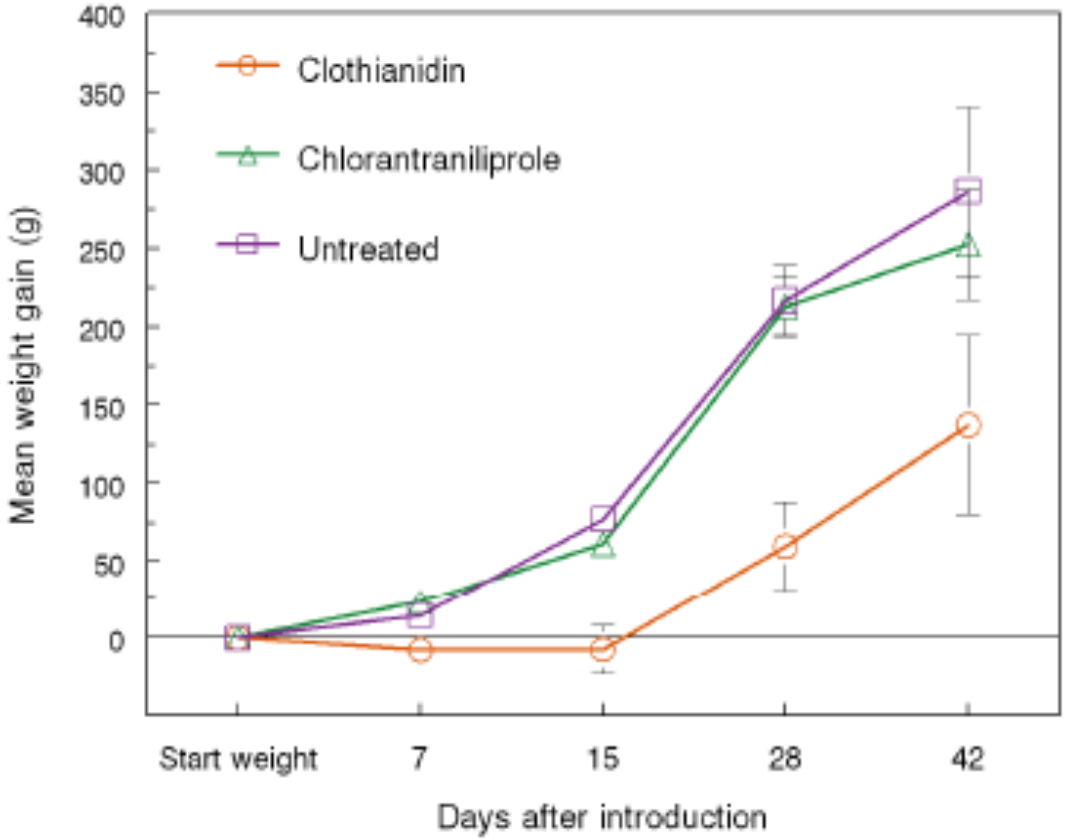


Figure 2. Colony weight change following exposure to treated turf. Mean (± SE) weight change (g) of *Bombus impatiens* colonies (10 per treatment) after foraging 6 days on insecticide-treated lawn turf with white clover and then being moved to an insecticide free site to openly forage for another 6 weeks (Repeated measures ANOVA: $F_{2,90} = 14.8$, $P < 0.001$; $F_{4,90} = 45.1$, $P < 0.001$; $F_{8,90} = 2.2$, $P < 0.05$ for treatment, date, and treatment×date interactions, respectively). Clothianidin-exposed colonies lagged behind the others on all dates ($F_{2,18} = 6.5$, 15.6. 12.7, 3.1; $P < 0.01$, 0.001, 0.001, 0.07 at 7, 15, 28, and 42 days after introduction, respectively

Queen bumble bees are produced in June-end season; overwinter, establish nests each spring

Tom Turpin, Purdue

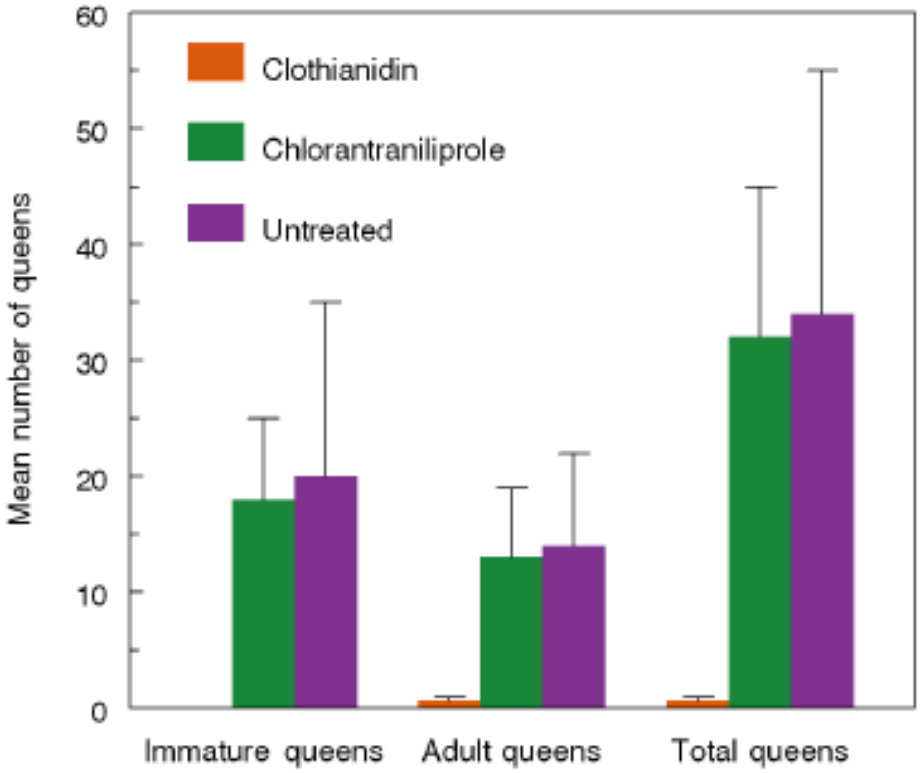


Figure 3. Queen production following exposure to treated turf. Mean (+ SE) numbers of queens produced by *Bombus impatiens* colonies that foraged for 6 days on insecticide-treated lawn turf with white clover and then were moved to an insecticide-free site to openly forage another 6 weeks (Friedman tests: Immature queens, $P = 0.03$; Adult queens, $P = 0.08$; Total queens, $P = 0.05$. Numbers of colonies (out of 10) that produced new queens were 0, 7, and 6 for clothianidin, chlorantraniliprole, and untreated hives, respectively. For the subset of colonies that produced new queens, those exposed to chlorantraniliprole-treated or untreated weedy turf produced similar numbers of immature, adult, and total queens (Kruskal-Wallis test, $P = 0.69$, 0.84, 0.95, respectively). Queens present in clothianidin exposed colonies likely represent the original mother queen.

Authors conclude:

- Results validate EPA label precautionary statements
  - Do not apply neonicotinoids to blooming nectar-producing plants if bees may visit the treatment area.
- Study showed that if weeds were mowed at time of application, new blooms of the weeds were not contaminated

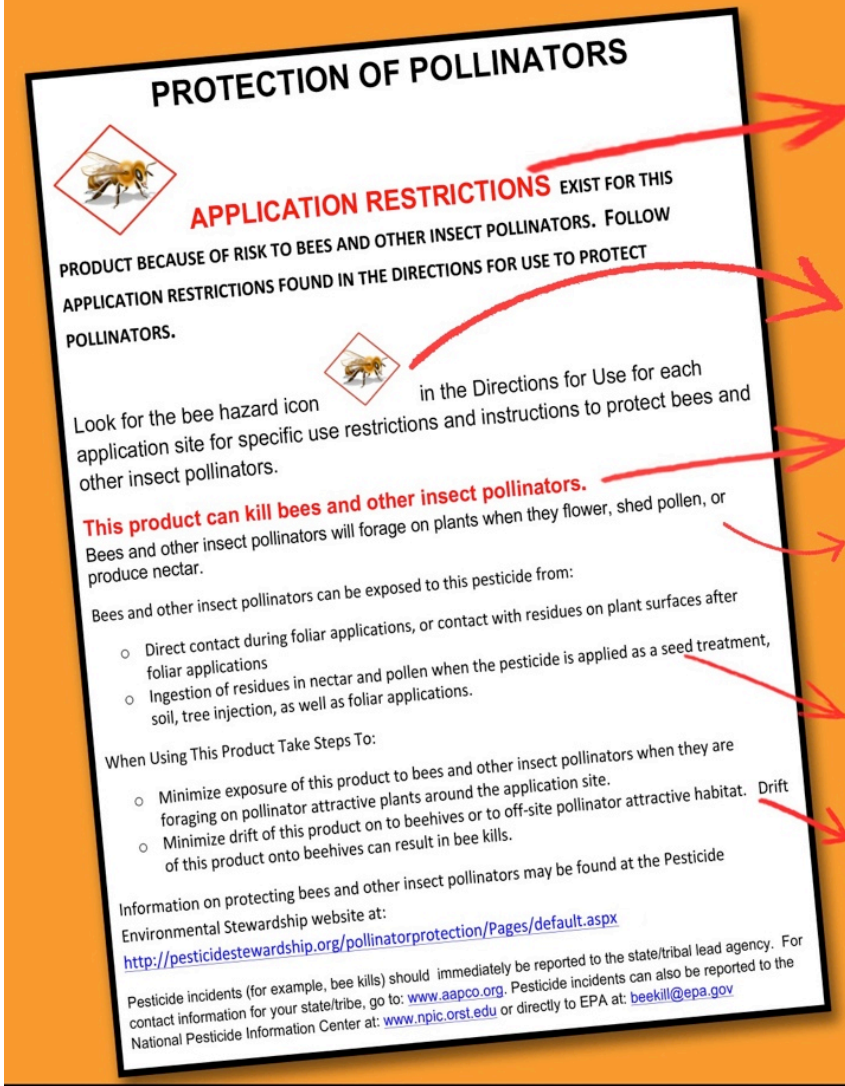
Label change for some neonicotinoids

New EPA bee icon

- The labels would be used for products containing imidacloprid, dinotefuran, chlothianidin and thiamethoxam — four of the most widely used neonicotinoids.
- Such chemicals kill insects with a nerve-poisoning effect.
- They're controversial because several scientific studies have suggested that even sublethal exposure can harm bee

THE NEW EPA BEE ADVISORY BOX

On EPA's new and strengthened pesticide label to protect pollinators



PROTECTION OF POLLINATORS

APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.

Look for the bee hazard icon in the Directions for Use for each application site for specific use restrictions and instructions to protect bees and other insect pollinators.

This product can kill bees and other insect pollinators.

Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar.

Bees and other insect pollinators can be exposed to this pesticide from:

- Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
- Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar applications.

When Using This Product Take Steps To:

- Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
- Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives can result in bee kills.

Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at:
http://pesticidestewardship.org/pollinatorprotection/Pages/default.aspx

Pesticide incidents (for example, bee kills) should immediately be reported to the state/tribal lead agency. For contact information for your state/tribe, go to: www.aapco.org. Pesticide incidents can also be reported to the National Pesticide Information Center at: www.npic.orst.edu or directly to EPA at: beekill@epa.gov

Alerts users to separate restrictions on the label. These prohibit certain pesticide use when bees are present.

The new bee icon helps signal the pesticide's potential hazard to bees.

Makes clear that pesticide products can kill bees and pollinators.

Bees are often present and foraging when plants and trees flower. EPA's new label makes it clear that pesticides cannot be applied until all petals have fallen.

Warns users that direct contact and ingestion could harm pollinators. EPA is working with beekeepers, growers, pesticide companies, and others to advance pesticide management practices.

Highlights the importance of avoiding drift. Sometimes, wind can cause pesticides to drift to new areas and can cause bee kills.

The science says that there are many causes for a decline in pollinator health, including pesticide exposure. EPA's new label will help protect pollinators.

EPA

Read EPA's new and strengthened label requirements: http://go.usa.gov/jHH4

Pollinator habitat enhancements

Passive effort: limit mowing of volunteer bee flowers; limit disturbance of nest habitats

Active effort: pollinator meadows created